Sir James Royal

1829

NAUTICAL PROPOSITIONS AND INSTITUTES; OR DIRECTIONS FOR THE PRACTICE OF NAVIGATION:

DRAWN,

From the AUTHOR's WRITINGS on this Subject, and Arranged in a regular & methodical Order; as they are to be learned, remembered and applied for USE at SEA, &c.

BY

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NAUTICAL PROPOSITIONS AND INSTITUTES, &c.

By S. DUNN.

SECTION I.

DIRECTIONS concerning the first Principles of Arithmetic.

1. NUMBERS are added together by the rule of Addition. They are subtracted by the rule of Subtraction. They are multiplied by the rule of Multiplication. They are divided by the rule of Division.

2. Numbers are reduced to lesser Denominations, when they are multiplied by as many of the lesser Denomination as make one of the next greater.

3. Numbers are brought to greater Denominations, when they are divided by as many of the lesser Denomination as make one of the next greater.

4. In Direct Proportion, the first and third Terms are of one name, and the second Term of the same name as that which is sought.

5. The Product of the second and third Terms divided by the first Term, gives the fourth Term.

SECTION II.

DIRECTIONS concerning Decimals and other Fractions.

1. A Decimal is a Fraction whose Denominator is Unity with a Cypher or Cyphers following it.

2. All other Fractions are called Vulgar Fractions.

3. When the Numerator is lefs than the Denominator, it is a Proper Fraction; but when the numerator is greater than the denominator, it is an Improper Fraction.

4. Equal Fractions, have their Numerators in the fame Ratio to each other as their Denominators.

5. Fractions having unequal Denominators, are to be reduced to equal ones, previous to Addition and Subtraction.

6. Fractions having equal Denominators, are added by adding together their Numerators, and fubtracted by fubtracting one Numerator from the other; retaining the Denominator unaltered.

7. Fractions are multiplied, when their Numerators are multiplied together for a new Numerator, and their Denominators multiplied together for a new Denominator.

8. Fractions are divided, when the Numerator of the Divifor is multiplied into the Denominator of the Dividend for a Denominator of the Quotient; and the Denominator of the Divifor multiplied into the Numerator of the Dividend for a Numerator of the Quotient.

9. Direct Proportionality in Fractions, is the fame as in Whole Numbers.

SECTION III.

Directions concerning the Ufe of Logarithms.

1. The Index of a Logarithm, is lefs by Unity (or 1) than the number of figures of whole numbers in the natural number to which it belongs.

2. When a Natural Number is partly a Whole Number and partly a Decimal; the Logarithm without its index, is the fame as it would be, if the Whole Number and Decimal together were a whole number, unfeparated by a point.

3. The Sum of the Logarithms, of two numbers, is the Logarithm of their Product.

4. The Difference of the Logarithms of two numbers, is the Logarithm of their Quotient.

5 In Direct Proportion; the fum of the Logarithms of the fecond and third Terms, leffened by the Logarithm of the firft Term, gives the Logarithm of the fourth Term.

6. Half the Logarithm of a number, is the Logarithm of its Square Root.

SECTION IV.

Directions for computing the Time of High Water at a given Place.

1ft. Add 1 to the year of our Lord, and divide the fum by 19, the remainder is the Golden Number.

2d. Sub-

Tides & Tide Table.

1st Add 1 to the given Year, the Sum Divide by 19, remains Golden Number. 2d From Gold.n No. subtract 1, multiply Remainder by 11, the Product Divide by 30, remains Epact. 3d Add, Epact, Day of Month, & for Jan. 0. Feb. 2. Mar. 1. Apr. 2. May 3. Jun. 4. Jul. 5. Aug. 6. Sep. 8. Oct. 8. Nov. 10. Dec. 10. the Sum Divide by 30; 4/5 of the Rem.r is Hour of Moon's being on Meridian. 4th To this add the Hour of Tide Tab. Sum is the Hour of High-

Water at	H.M	at	H.M	at	H.M	Capes & Entrance of Rivers, &c. High Water at	H.M
Aberdeen	0.45	Edam	1.30	Needles	8.15	Amazon R.	6.0
Aldborough	9.45	Edystone	5.30	Newcastle	5.15	Blanco C.	10.0
Alderney	0.0	Embden	0.0	Nieuport	11.45	Bajador C.	0.0
Amsterdam	3.0	Falmouth	5.30	Nore	0.0	Canary I.	3.0
Andrews St.	2.15	Flushing	0.45	Orkneys	9.45	Cantin C.	0.0
Antwerp	6.0	N. Foreland	10.30	Ostend	11.45	Cape Clear	4.30
Archangel	6.0	S. Foreland	10.30	Plymouth	6.0	Cape Corse	3.30
Ashley R.	0.45	Fowey	5.15	Portland	9.0	Corunna	3.0
Augustin St.	4.30	Gibralter	0.0	Portsmouth	11.15	Loire R.	3.0
Bayonne	3.30	Graveling	0.0	Queenboro'	0.0	Madeira	0.0
Beachy	0.0	Gravesend	1.30	Ree Isle	3.0	Maes R.	1.30
Bellisle	3.36	Guernsey	1.30	Rochfort	4.15	Severn R.	6.0
Bermuda	7.0	Hamburgh	6.0	Rochelle	3.45	Seyne R.	9.0
Berwick	2.30	Haerlem	9.0	Rochester	0.45	Tees R.	3.0
Bourdeaux	3.30	Harwich	11.15	Rotterdam	3.0	Thames R.	1.30
Bologne	11.0	Havre	9.0	Scarborough	3.45		
Bremen	6.0	Helens St.	10.30	Scilly	3.45		
Brest	3.15	Hull	6.0	Senegal	10.30		
Bristol	7.0	Kinsale	5.15	Shereness	0.0		
Bridgwater	7.0	Lands end	5.30	Shoreham	10.0		
Cadiz	4.30	Leith	2.0	Southampton	0.0		
Caen	9.0	Leostoff	9.45	Start	7.0		
Calais	11.30	Lisbon	2.15	Stockton	5.15		
Camarthen	5.15	Lizard	7.30	Teneriff	3.0		
Catness	9.0	London	3.0	Texel Isle	7.0		
Cowes	10.30	Lundy	5.30	Tinmouth	3.0		
Dartmouth	6.0	Lynn	6.0	Topsham	6.0		
Diepe	10.30	Man Isle	9.0	Torbay	5.15		
Dover	11.30	Maloes	6.0	Ushant	4.30		
Downs	2.15	Margate	11.15	Waterford	6.30		
Dublin	9.15	Milford	6.0	Weymouth	6.45		
Dunbar	9.0	Minehead	6.0	Whitby	3.10		
Dundee	2.15	Mounts bay	4.30	Wight Isle	9.0		
Dungeness	9.45	Nantes	3.0	Yarmouth	9.45		
Dunnose	9.45	Naze	11.15	Youghall	4.30		

The Moon's Meridian Transit; makes Tides in open Seas, nearly under that & the opposite Meridian. In Rivers; the Time is accelerated or retarded by their Positions, Lengths & other accidental Causes. To ascertain the Bearing of the Moon, at Time of High Water, some allow 6 Hours to 8 Points of the Compass Card; but this is not true from the Properties of the Sphere.

Golden No. 0 is 19.

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2d. Subtract 1 from the Golden Number, multiply the remainder by 11 and divide the product by 30, the remainder is the Epact.

3d. The numbers for the months are as follows.

January	0.	July	5.
February	2.	August	6.
March	1.	September	8.
April	2.	October	8.
May	3.	November	10.
June	4.	December	10.

4th. Add together the Epact, the number for the Month, and the Day of the month; divide the sum by 30, and the remainder is the Moon's age in days.

5th. Multiply that age by 4, and divide the product by 5, the quotient is the hour of the Moon's being on the Meridian that day.

6th. To that hour add the hours for the given place, as it is in the Tide Table, and the sum is the hour of High Water at that place.

7th. The day begins at Noon, 12 hours later than according to the common account, and continues to 24 hours the next noon.

8th. The High Water happens at the end of a little less than 25 hours, likewise at the end of every 12 hours and half nearly.

SECTION V.

Directions concerning Plane Triangles.

1. Every circle contains 360 Degrees, and each Degree 60 Minutes.

2. A Plane Angle is the Inclination of two straight lines to each other, and which meet at a Point.

3. A Plane Triangle hath three Angles, which together are equal to two Right Angles, or 180 Degrees.

4. In a Right-angled Plane Triangle; its two lesser Angles together are equal to one Right Angle, or 90 Degrees.

5. The Sides of all Plane Triangles, are directly proportional to the Sines of their opposite Angles.

6. The Complement of an Angle, is its remainder to 90 degrees. The Supplement of an Angle, is its remainder to 180 Degrees.

7. In any Plane Triangle; As the Sum of two sides is to their Difference, so is the Tangent of half the sum of the opposite Angles, to the Tangent of half the difference of those Angles.

8. Half the difference of two numbers added to their half sum, gives the greater number; and subtracted from the half sum gives the lesser number.

9. An Oblique-angled Triangle hath its three sides unequal. Its longest side is the Base, the other two sides are called Sides. The Perpendicular falls on the Base from the Angle opposite thereto, forming the greater and lesser Segment.

10. As the Base, is to the Sum of the sides; so is the Difference of the sides, to the Difference of the Segments of the base.

11. Half the Difference of the Segments added to Half the Base, gives the Greater Segment; and subtracted from Half the Base gives the Lesser Segment.

12. When Angles are exceeding small; their arches may be treated as the Sines of them, without sensible error.

SECTION VI.

DIRECTIONS concerning Right-angled Plane Triangles.

1. In a Right-angled Plane Triangle, the longest side is the Hypothenuse, the shortest side the Perpendicular, and the other side the Base.

2. As the Base, is to the Perpendicular; so is the Radius, to the Tangent of the Angle at the Base.

3. As the Perpendicular, is to the Base; so is the Radius, to the Tangent of the Angle at the Perpendicular.

4. As the Sine of an Angle, is to its opposite Side; so is the Sine of another Angle of the same Triangle, to its opposite Side.

5. As a Side, is to the Sine of its opposite Angle; so is another Side of the same Triangle, to the Sine of its opposite Angle.

6. The Square of the Hypothenuse, is equal to the Sum of the Squares of the Base and Perpendicular.

7. The Hypothenuse may represent Radius, when the Base and Perpendicular represent Sine and Cosine.

8. The Base or Perpendicular may represent, one a Radius and the other a Tangent, when the Hypothenuse represents a Secant.

9. The Things themselves and what they represent, will be directly proportional.

SECTION VII.

DIRECTIONS concerning the Dimensions and Figure of the Earth; the Meridians; Points of the Compass; the Variation, Lee-way, Course, Distance, Log-line, and Half-minute Glass; with Rules for knowing when they are truly proportioned to each other.

1. The Circumference of a Meridian on the surface of the Earth and Sea is 360 Degrees or 21600 nautical Miles. Each of these degrees is a Degree of Latitude, and each mile is a Minute of Latitude.

2. The Circumference of the Equinoctial Line on the surface of the Earth and Sea is 360 Degrees or twice 180 Degrees. Each of

these

theſe degrees is a Degree of Longitude containing 60 Minutes of Longitude.

3. The true North and true South Points of the Horizon, are in the direction of a Meridian, and all the other true points of the Compaſs are deduced from theſe, as in the Diviſions and Subdiviſions of the Compaſs Card.

4. The Variation of the Compaſs, is the number of Degrees and Minutes in the circumference of its circle, which the North Point of the Card declines Eaſtward or Weſtward from the true North Point of the Meridian.

5. Leeway, is the Angle of Difference between the Courſe which a ſhip really makes, and the courſe which ſhe ſeems to make by the poſition of her Head and Stern.

6. The Courſe of a ſhip at ſea is not that which ſhe appears to make in ſailing by the Compaſs Card; but what is compared with the true points of the Horizon. Therefore, the apparent courſe is reduced to the true courſe by adding or ſubtracting the Variation and Leeway, as the caſe requires.

7. The true Courſe is reckoned from the true North toward the true Eaſt or true Weſt, to 8 points or 90 degrees. The like from the true South toward the true Eaſt or true Weſt.

8. The Complement of the Courſe, is its Remainder to 90 Degrees.

9. The Diſtance ſailed is meaſured in Nautical miles, which are between a ſixth and a ſeventh part of the whole, longer than Engliſh ſtatute miles.

10. The Diſtance between Knot and Knot on the Log-line, whereby the ſhip's Diſtance ſailed is meaſured, ſhould be 51 Engliſh feet, when the Half-minute glaſs runs exactly 30 Seconds of time.

11. If the Diſtance between knot and knot be either more or leſs than 51 feet, the Seconds of the half-minute glaſs muſt be more or leſs reſpectively, in the Direct Proportion of 51 to 30.

12. If the Seconds of the Half minute Glaſs are more or leſs than 30, the diſtance between knot and knot on the log-line muſt be more or leſs reſpectively in the direct proportion of 30 to 51.

13. When the Log-line and Half-minute Glaſs are not rightly proportioned to each other.

Multiply the diſtance in Engliſh feet, between knot and knot, by the number of knots run per half-minute glaſs, and 30 times that product is a Dividend. Then, multiply the number of ſeconds of time which the glaſs runs, by 51, and the product is a Diviſor. Make Diviſion, and the Quotient is the number of Nautical Miles per hour which the ſhip runs.

14. A Pendulum that ſwings Seconds of time, meaſures $39\frac{2}{10}$ Inches Engliſh meaſure, from the centre of ſuſpenſion to the centre of motion, ſuppoſing it a ſmall Bullet with a fine Thread or Wire.

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SECTION VIII.

DIRECTIONS for computing the usual Cases of Plain Sailing by Logarithms; also for working by the Table of Difference of Latitude and Departure.

1. To find the Departure.

As the Radius or Sine of 90°
Is to the Distance sailed in miles,
So is the Sine of the Course in degrees,
To the Departure in miles.

2. To find the Difference of Latitude.

As the Radius or Sine of 90°
Is to the Distance sailed in miles;
So is the Cosine of the Course in degrees,
To the Difference of Latitude in miles.

3. Departure is either Easting or Westing.
Difference of Latitude is either Northing or Southing.

4. To find the Course.

As the Difference of Latitude in miles,
Is to the Departure in miles;
So is the Radius or Sine of 90°
To the Tangent of the Course in degrees.

5. To find the Distance sailed.

As the Sine of the Course in degrees,
Is to the Departure in miles;
So is the Radius or Sine of 90°
To the Distance sailed in miles.

6. To find the Course.

As the Distance sailed in miles,
Is to the Radius or Sine of 90°
So is the Difference of Latitude in miles
To the Cosine of the Course in degrees.

7. If a ship in North Latitude makes Northing, the Difference of Latitude added to the Latitude sailed from, gives the North Latitude come to.

8. If a ship in South Latitude makes Southing, the Difference of Latitude added to the Latitude sailed from, gives the South Latitude come to.

8. If

9. If a ſhip in North Latitude makes Southing, or a ſhip in South Latitude makes Northing, and the Difference of Latitude made is more than the Latitude ſailed from, the ſhip is in a contrary Latitude, by the Difference between them in degrees and minutes.

10. The Difference of Latitude made good, and the Departure made good, are each found from ſeveral Courſes and Diſtances, by help of the Traverſe Table. Then,

11. The Courſe made good and Diſtance ſailed made good, are found by the foregoing Canons.

SECTION IX.

DIRECTIONS for computing the uſual Caſes in Mercator's or Wright's ſailing.

1. If two places are both in North Latitude or both in South Latitude, the Difference between their Meridional Parts is their Meridional Difference of Latitude.

2. If two places are one of them in North latitude and the other in South Latitude, the Sum of their Meridional Parts, is their Meridional Difference of Latitude.

3. Longitude from London is reckoned from the Meridian of London at the Equinoctial, Eaſtward to 180 degrees, and Weſtward to 180 degrees. The like for any other Meridian.

4. To find the Difference of Longitude.

As the true Difference of Latitude in minutes,
Is to the Departure in miles;
So is the Meridional Difference of ~~Longitude~~ Latitude in parts,
To the true Difference of Longitude in minutes.

5. As the Meridional Difference of Latitude in parts,
Is to the true Difference of Longitude in minutes;
So is the Radius or Sine of 90
To the Tangent of the Courſe in degrees.

SECTION X.

DIRECTIONS for computing the Caſes of Parallel Sailing.

1. A ſhip ſailing conſtantly Eaſtward or Weſtward without deviating toward the true North or true South point of the Horizon, ſails in a Parallel of Latitude.

2. As the Coſine of the Latitude ſailed in,
Is to the Radius or Sine of 90°
So is the Diſtance ſailed in miles,
To the Difference of Longitude in minutes.

3. As the Radius or Sine of 90°
Is to the Cosine of the Latitude sailed in;
So is the Difference of Longitude in minutes,
To the Distance sailed in miles.

SECTION XI.

DIRECTIONS for computing Middle Latitude Sailing.

1. The Half Sum of the Latitude sailed from, and the Latitude come to, is the Middle Latitude.

2. To find the Difference of Longitude.
As the Cosine of the Middle Latitude,
Is to the Radius or Sine of 90°
So is the Departure in miles,
To the Difference of Longitude in minutes.

3. To find the Departure.
As the Radius or Sine of 90°
Is to the Cosine of the Middle Latitude;
So is the Difference of Longitude in minutes.
To the Departure in miles.

4. In Parallel Sailing the Distance sailed is the Departure in miles; and the Latitude sailed in, is the Middle Latitude.

SECTION XII.

DIRECTIONS concerning Currents.

1. A ship sailing where there is a Current, sails between the direction shewn by the position of her Head and Stern, and the direction of the Current.
2. The Course and Distance sailed, as they appear by the log and half-minute glass are taken; also, the Course, and Drift of the Current per hour.
3. From a given point a line is drawn, shewing the hourly Course and Distance sailed by the pressure of the wind on her sails.
4. From the same point another line is drawn, shewing the hourly Course and Distance driven by the Current.
5. A Parallelogram is compleated by adding the opposite equal sides.
6 The Diagonal of this Parallelogram, drawn from the given point, is the Path of the ship.
7. A Current is accurately taken, by observation on the Ship's Wake.

SECTION XIII.

DIRECTIONS concerning the Log, and inferring the Place of the Ship from the Courses and Distances sailed.

1. In long Voyages the Log should be hove every Hour; in short Voyages every two Hours.

2. If the Distance between Knot and Knot on the Log-line be supposedly divided into Ten equal Parts, they will be more easily added up in the Reckoning.

3. When two or more Courses are very nearly alike; they may be added together and divided by the Number of Courses, to get a Medium; and the Sum of the correspondent Distances sailed, used with that Medium Course.

4. When the Distances sailed have been long, the Longitude should be inferred at short Intervals of Time. But in short Distances sailed, the Longitude may be inferred at longer Intervals of Time.

5. The Error arising from one such Inferrence, should not exceed a Minute of Longitude.

SECTION XIV.

DIRECTIONS for applying the different Kinds of Sailing at different Places.

1. The Tropic of Cancer, on the Earth and Sea, is a Circle at the distance of 23 Degrees and 28 Minutes Northward from the Equinoctial Line.

2. The Tropic of Capricorn, is a like Circle at the same distance Southward of the Equinoctial.

3. The Torrid Zone is the space between the Tropics.

4. The North Temperate Zone, extends 43 Degrees and 4 Minutes more Northwardly than the Torrid Zone, or to within 23 Degrees and 28 Minutes of the North Pole.

5. The South Temperate Zone extends the like distance, more Southward than the Torrid Zone.

6. The remaining parts, Land or Sea, round the North Pole, are in the North Frigid Zone.

7. The like parts round the South Pole, are in the South Frigid Zone.

8. Plain Sailing may be applied near the Equinoctial.

9. Mercator's Sailing should be applied near the Poles.

10. Either Mercator's, or Middle Latitude Sailing, should be applied at other places.

SECTION XV.

DIRECTIONS for adjusting Hadley's Octant and Sextant, in order to make an Observation.

1. The Beginning of the Index should be put to the Beginning of the Octant or Sextant, previous to every Adjustment.

2. The Foot of the Great Mirror should be formed at Right Angles to the Plane of the Cell, that is to hold the Glass.

3. The Great Mirror has then its Foot screwed down flat, on the Plane of the Index, near the centre.

4. The Sight Hole in the Eye Piece, should be the same Distance from the plane of the instrument, as the Line between the quicksilvered and the unquicksilvered part on the small Mirror.

5. Hold the Instrument horizontally, and move the small Mirror, until an horizontal Line at a Distance, appears continued as one, both on and off the quicksilvered part of the small Mirror.

6. Put the beginning of the Index to the beginning of the Instrument, and holding the Instrument vertically, turn the small Mirror, until any object appears perfect; partly on the quicksilvered and partly on the unquicksilvered part of the small Mirror.

7. The Objects whereby both of these adjustments may be correctly made, should not be less than half a mile off.

8. Some Instruments have the Foot of the Great Mirror, not at Right Angles to the Glass; such may be adjusted by the following method.

9. Let the Eye-hole in the Eye piece be the same height from the Plane of the Instrument, as the Line between the quicksilvered and unquicksilvered part of the small Mirror.

10. Cut out a parallelogram Piece of dark Paper of the length of the Great Mirror, and such a breadth, that when stuck on the lower part of the Great Mirror, it may cover it to the height of the quicksilvered part on the small Mirror.

11. Adjust both of the Mirrors, until the reflected top of the Paper appears coincident with the Line between the quicksilvered and unquicksilvered Part of the small Mirror.

12. If it may be supposed, that the great and small Mirrors do not both stand exactly perpendicular to the Plane of the Instrument, after the foregoing Adjustment, it may be verified farther thus.

13. Take a thin plate of Brass whose length is that of the Great Mirror, with its foot at right angles to its height, and height such that when placed upright on its foot before the Great Mirror, the Edge of the forementioned Paper, the Edge of this Plate, the Line between the quicksilvered and unquicksilvered part on the small mirror, and the Sight-hole, may be the same Distance from the Plane of the Instrument.

14. Adjust both the great and small Mirror until these three Edges

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by direct and reflected viſion are in one, and it is the horizontal adjuſtment required.

SECTION XVI.

Directions for joining the Objects obſerved, in uſing Hadley's Octant or Sextant.

1. The Line of Separation between the quickſilvered and the unquickſilvered part of the ſmall Mirror, may not be improperly called the Object Line.

2. In all obſervations with the inſtrument, the Objects ſhould be brought at contact with each other in the Object Line.

3. The Adjuſtment of the Inſtrument ſhould be re-examined after the Obſervation.

SECTION XVII.

Directions for taking the Meridian Altitude of the Sun or Moon, with Hadley's Octant or Sextant.

1. The lower Limb of the Sun is always brought to ſweep the Horizon of the Sea.

2. The Sun's Semidiameter muſt be added, but the Refraction and Dip correſponding to that altitude ſubtracted, to get the true altitude of the Sun's Centre.

3. The Moon's lower or upper Limb is brought to the Horizon, that of the two which is viſible.

4. When the lower Limb of the Moon is obſerved, the Moon's Semidiameter muſt be added, but the Refraction and Dip ſubtracted, to get the altitude of the Moon's Centre.

5. When the upper Limb of the Moon is obſerved, the Moon's Semidiameter muſt be ſubtracted, alſo the Refraction and Dip muſt be ſubtracted, to get the altitude of the Moon's Centre.

6. The Altitude thus found is only that which reſpects the Horizon of the Sea. But the Moon's true Altitude with reſpect to the Horizon paſſing through the Earth's Centre is greater by the Parallax in Altitude.

7. As the Radius or Sine of 90°
Is to the Coſine of the Moon's Altitude;
So is the Moon's horizontal Parallax in Seconds,
To the Parallax in Altitude in Seconds.

8. A Star is brought to touch the Horizon of the Sea, and the Refraction and Dip are ſubtracted.

SECTION XVIII.

DIRECTIONS concerning the Meridian Altitudes of the Celestial Bodies, at different Places of the Earth and Seas.

1. On any Day, the Altitude of the Sun is greatest when his Centre is on the Meridian of the place of observation.

2. A Direct Observation is made by bringing the Object to the Horizon before you.

3. In the North-temperate and North-frigid Zones, you face the South, to see the Sun on the Meridian.

4. In the South-temperate and South-frigid Zones, you face the North, to see the Sun on the Meridian.

5. In the Torrid Zone, you sometimes face the North, and at other times the South, to see the Sun on the Meridian.

6. In the Torrid Zone, North of the Equinoctial Line, you face the South to see the Sun on the Meridian when the Sun hath South Declination, and when his North Declination is less than the Latitude of the Place.

7. In the Torrid Zone, South of the Equinoctial Line, you face the North to see the Sun on the Meridian when the Sun hath North Declination, and when his South Declination is less than the Latitude of the Place.

8. If in the Torrid Zone, North of the Equinoctial, you face the North to see the Sun on the Meridian; or in the Torrid Zone South of the Equinoctial, you face the South to see the Sun on the Meridian: in either of these cases, the Latitude is less than the Sun's Declination.

9. The Meridian Altitude of the Equator, is the Co-latitude, or it's remainder to 90°.

10. The Sun on the Meridian, never exceeds 23 Degreees and 28 Minutes, above or under the Meridian Altitude of the Equator.

11. In the Frigid Zones, the Sun (also the Stars) may have two Meridian Altitudes; one above, the other under the Pole.

12. In the other Zones, the Stars near the Poles, may have the like.

SECTION XIX.

DIRECTIONS for taking the Latitude at Sea, by Meridian Altitudes of the Sun.

1. Take the Meridian Altitude of the Sun's lower Limb, and add thereto the Semidiameter, but subtract the Refraction and Dip, this gives the Meridian Altitude of the Sun's Centre.

2. If

2. If you face the South and the Sun hath $\left\{\begin{array}{l}\text{South}\\ \text{North}\end{array}\right\}$ Declination, $\left\{\begin{array}{l}\text{add}\\ \text{subtract}\end{array}\right\}$ the Declination $\left\{\begin{array}{l}\text{to}\\ \text{from}\end{array}\right\}$ the Meridian Altitude; this gives either the Co-latitude, or its Supplement.

3. If you face the North and the Sun hath $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ Declination, $\left\{\begin{array}{l}\text{add}\\ \text{subtract}\end{array}\right\}$ the Declination $\left\{\begin{array}{l}\text{to}\\ \text{from}\end{array}\right\}$ the Meridian Altitude; this gives either the Co-latitude, or its Supplement.

4. If you face the North, and the Sun's Declination is North, and the Meridian Altitude added to the Declination makes exactly 90° Or otherwise, if you face the South, and the Sun's Declination is South, and the Meridian Altitude added to the Declination makes exactly 90° in either of these two cases, you are at the Equinoctial Line.

5. If you face the $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ and the Sun's Declination is $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ and the Meridian Altitude added to the Declination makes more than 90° you are in $\left\{\begin{array}{l}\text{North}\\ \text{South}\end{array}\right\}$ Latitude, and the Meridian Altitude added to the Declination gives the Supplement of the Co-latitude. Take this Supplement from 180° the Remainder is the Co-latitude. Or, take 90° from the Supplement, the Remainder is the Latitude.

SECTION XX.

DIRECTIONS for taking the Latitude at Sea, by Meridian Altitudes of the Fixed Stars.

1. Fixed Stars change their Declination a little every Year, either increasing or decreasing,

2. Before they are used in finding the Latitude, their Declinations must be corrected to the time of Observation.

3 Their Semidiameter is nothing, but their Refraction and Dip, are both to be subtracted from their observed Meridian Altitudes, to get the true Altitudes of the Centre.

4. The Latitude is determined by having the Meridian Altitude of the Centre of a Fixed Star, as it is determined by that of the Sun.

SECTION XXI.

Directions for finding the Diſtance of the viſible Horizon at Sea.

1. The Diameter of the Earth's Globe is 7942 Engliſh Miles nearly, or 41933760 Engliſh Feet, and the Logarithm of theſe Feet is 7,6225639.

2. In an Engliſh Mile are 5280 Feet, whoſe Logarithm is 3,7226339, whoſe double is 7,4452678, which being taken from the former Logarithm, the Remainder is 0,1772961, or being contracted, it is 0,1773.

3. To this conſtant Logarithm 0,1773, add the Logarithm of the Height of the Eye above the ſurface of the Sea in Feet, and Half that Sum is the Logarithm of the Diſtance in Miles, which you may ſee the Surface of the Sea, from that Height.

4. From the Double Logarithm of the Diſtance, which the ſurface of the Sea can be ſeen in Miles, ſubtract the conſtant Logarithm 0.1773; and the Remainder is the Logarithm of the Height of the Eye above the Surface of the Sea in Feet.

SECTION XXII.

Directions for knowing the Hour at the firſt Meridian, having the Hour at the Ship and it's Longitude.

1. The Meridian of St. Paul's, London, is commonly called the firſt Meridian, by Britiſh Navigators; but the Britiſh aſtronomical Tables are adapted to the Meridian of Greenwich Obſervatory, which is nearly 6 Minutes of a Degree of Longitude, eaſtward from St. Paul's, London.

2. Every Degree of Longitude, Eaſtward or Weſtward from the firſt Meridian, anſwers to 4 Minutes of Time, and every Hour of Time anſwers to 15 Degrees of Longitude.

3. When a Ship is any where, on the ſame Side of this firſt Meridian, it is the ſame Hour and Minute of the Day or Night at the Ship, as at London.

4. When the Ship is {Eaſtward / Weſtward} of the firſt Meridian it is {more / leſs} time of the Day or Night, at the Ship, than it is at London at the ſame inſtant.

5. When the Ship is {Eaſtward / Weſtward} of this firſt Meridian, the Hour at the Ship {diminiſhed / augmented} by the Ship's Longitude in Time from London, gives the Hour at London.

SEC-

SECTION XXIII.

DIRECTIONS for knowing the Sun's true Declination, when the Longitude of the Ship is nearly known.

1. The Sun's Declination in the British astronomical Tables, is computed for every Day in the year at Noon, as it is found either at Greenwich or London.

2. Near the time of the Summer and Winter Solstices, the Declination is nearly the same during 24 hours; but near the time of the Equinoxes the Declination changes considerably during 24 Hours.

3. As 24 Hours, is to the daily difference of Declination; so is any less Number of Hours, to the change of Declination in that Interval. This {added to / subtracted from} the Declination of the foregoing Noon for Greenwich, when the Declination is {increasing / decreasing} gives the Declination at the given Hour.

4. Thus, the Sun's Declination is found for any given Hour at the Ship, when the Ship's Longitude is known somewhat near the Truth.

SECTION XXIV.

DIRECTIONS for finding the Variation of the Compass at Sea by Amplitudes.

1. The true East, true West, true North and true South Points of the Horizon, do not appear at Sea, but are invisible; nevertheless they are understood to exist.

2. The false East, false West, false North and false South Points of the Horizon, are shewn by the Card, in either the Steering Compass or the Azimuth Compass.

3. When the lower Edge of the Sun appears Half his Diameter above the Horizon, the Centre of the Sun is then nearly in the Horizon; this is the time for taking the Amplitude, either at Sun Rising or Sun Setting.

4. The true Amplitude is reckoned from the true East at Sun Rising, and from the true West at Sun Setting; toward the true North or true South, in Degrees and Minutes.

5. The false Amplitude is taken and reckoned from the false East at Sun Rising, and from the false West at Sun Setting; toward the false North or false South, in Degrees and Minutes.

6. Whilst the Sun hath North Declination, the Sun riseth Northward of the true East, and sets Northward of the true West.

7. Whilst the Sun hath South Declination, the Sun riseth Southward of the true East, and sets Southward of the true West.

8. As

8. As the Cosine of the Latitude,
Is to the Radius or Sine of 90°
So is the Sine of the Sun's Declination,
To the Sine of the true Amplitude.

9. In the Circumference of a small Circle, represent the true East and true West, true North and true South; and from the true East for Sun Rising, or true West for Sun Setting, set off the true Amplitude toward the true North or true South, to the true horizontal Place of the Sun.

10. From that Place of the Sun, set off the false Amplitude, to the false East or false West, shewn by the Compass Card.

11. If the false Amplitude coincides with and is equal to the true Amplitude, the false North will coincide with the true North and there will be no Variation.

12. The false North declines as much, and the same Way, from the true North, as the false East doth from the true East, or the false West doth from the true West.

13. When the false Amplitude and true Amplitude, are both Northwardly or both Southwardly, their Difference is the Variation.

14. When the false Amplitude and true Amplitude, are one Northwardly and the other Southwardly, their Sum is the Variation.

15. When the $\left\{\begin{array}{l}\text{true}\\\text{false}\end{array}\right\}$ Amplitude $\left\{\begin{array}{l}\text{northwardly}\\\text{southwardly}\end{array}\right\}$ is $\left\{\begin{array}{l}\text{greatest}\\\text{least}\end{array}\right\}$ at Sun $\left\{\begin{array}{l}\text{Setting}\\\text{Rising}\end{array}\right\}$ the Variation is Eastwardly.

16. When the $\left\{\begin{array}{l}\text{true}\\\text{false}\end{array}\right\}$ Amplitude $\left\{\begin{array}{l}\text{northwardly}\\\text{southwardly}\end{array}\right\}$ is $\left\{\begin{array}{l}\text{greatest}\\\text{least}\end{array}\right\}$ at Sun $\left\{\begin{array}{l}\text{Rising}\\\text{Setting}\end{array}\right\}$ the Variation is Westwardly.

17. If any Difficulty ariseth concerning this, a small Circle should be drawn and quartered, and in the Circumference the true and false Amplitudes set off, for shewing the Addition or Subtraction to get the Variation.

SECTION XXV.

Directions for finding the Variation of the Compass at Sea, by Azimuths.

1. The true North and true South Points of the Horizon, do not appear at Sea, but are invisible, nevertheless they are understood to exist.

2. The false North and false South Points of the Horizon, are shewn by the Card in either the Steering Compass or the Azimuth Compass.

Calculation of the TIDES.

1784:

1. Required the time of High Water at London Bridge May 28?

Calculation. 1784
1
19) 1785 (93
171
75
57
18 Golden N°. 17
11
30) 187 (6
180
Epact 7
N°. Month ... 3
Day 28
☽ Age 8
4
5) 32 (
☽ South .... 6.h 24′
3
High Water .... 9.h 24′

1790

2. Required, time of High Water at Dover October 12th?

Calculation 1790
1
19) 1791 (94
171
81
76
5 Golden N°. ... 4
11
30) 44 (1
30
Epact 14
N°. Month 8
Day 12
☽ Age 4
4
5) 16 (
☽ South 3.h 12′
0.
High Water 3.h 12′

3. Required, the High Water at Lizard Jan.y 1. 1821?

Calculation. 1821
1
19) 1822 (95
17 Golden N°. .. 16
11
30) 176 (5
Epact 26
N°. Month 0
Day ... 1
☽ Age 27
4
5) 108 (
☽ South 21.h 36′
7 30
High Water 5.h 6′

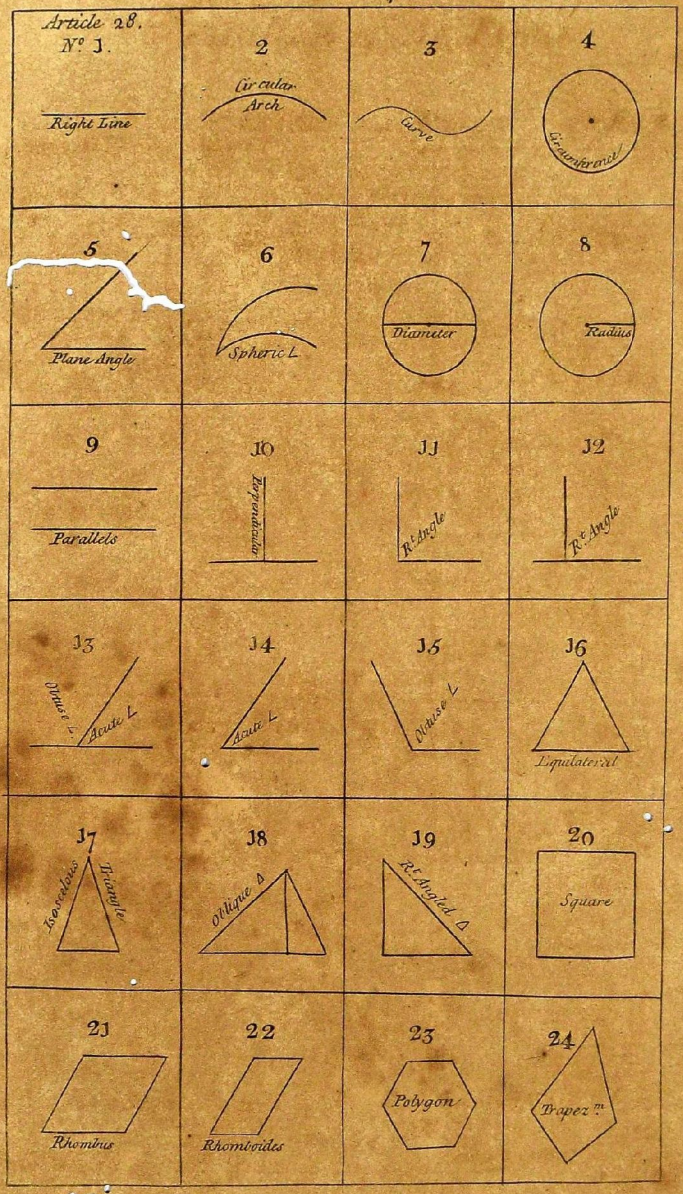
4. Required, the High Water at Deal June 6th. 1851?

Calculation 1851
1
19) 1852 (97
9 Golden N°. 8
11
30) 88 (2
Epact 28
N°. Month 4
Day 6
☽ Age 8
4
5) 32 (
☽ South 6.h 24′
2 . 15
High Water 8 . 35

S. Dunn delin.t

Publish'd a[...] [...]liament Nov.r 17th 1777. by S. Dunn.

Geometrical Definitions.



Lines or Angles given are marked thus |

Lines or Angles required are marked thus ∘

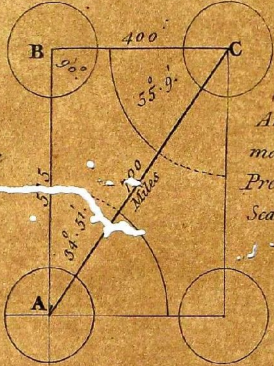
S. Dunn delint.

Published according to Act of Parliament Novr. 17th. 1777, by S. Dunn.

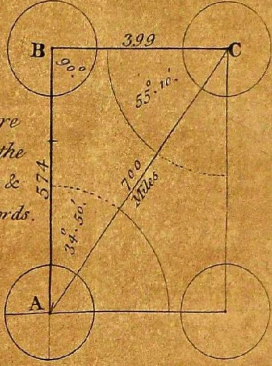
Plain Sailing.

By Construction, in it's Six Usual Cases.

Case 1.

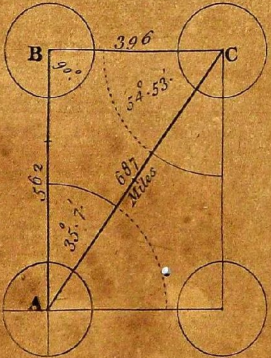


Angles are made by the Protractor & Scale of Chords.

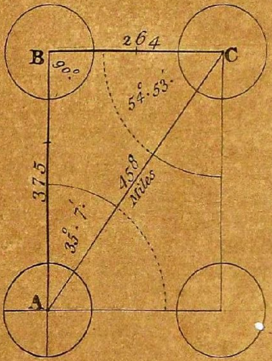


Case 2.

Case 3.

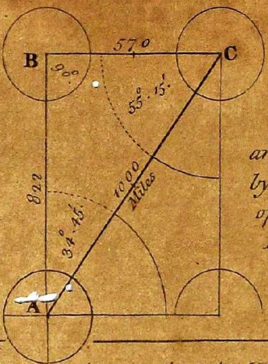


These may be used for Examples.

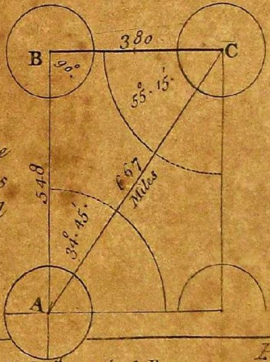


Case 4.

Case 5.



Sides are made by Scales of equal Parts



Case 6.

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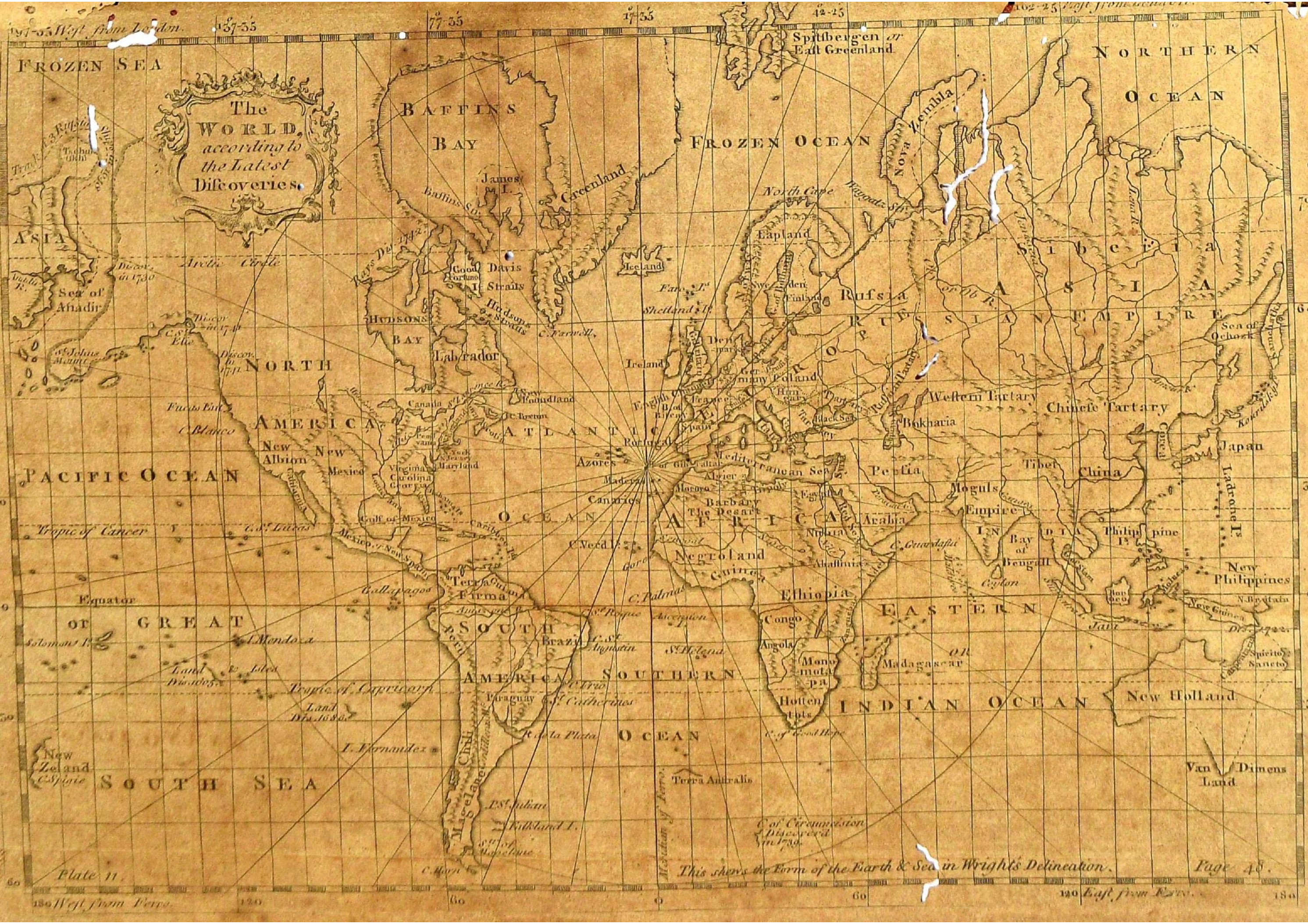


The WORLD, according to the Latest Discoveries.
FROZEN SEA
BAFFINS BAY
FROZEN OCEAN
NORTHERN OCEAN
Spitbergen or East Greenland
Greenland
James I.
Davis Straits
Hudsons Straits
HUDSONS BAY
Labrador
Nova Zembla
North Cape
Lapland
Iceland
Ireland
Sweden
Finland
Rufsia
RUSSIAN EMPIRE
Siberia
ASIA
Sea of Anadir
Sea of Ochozk
Arctic Circle
NORTH AMERICA
New Albion
New Mexico
Canada
New Foundland
C. Breton
Virginia
Carolina
Georgia
Maryland
Gulf of Mexico
Mexico
PACIFIC OCEAN
Tropic of Cancer
ATLANTIC OCEAN
Azores
Madeira
Canaries
C. Verd I.
Portugal
Spain
France
Germany
Poland
Mediterranean Sea
Black Sea
Western Tartary
Chinese Tartary
Bokharia
Persia
Tibet
China
Japan
Corea
Moguls Empire
INDIA
Bay of Bengall
Ceylon
Arabia
Egypt
Nubia
Barbary
The Desart
AFRICA
Negroland
Guinea
Abassinia
Ethiopia
C. Guardafui
Congo
Angola
Manomotapa
Hottentots
Madagascar
Philippine I.
Ladrone I.
New Guinea
New Philippines
Java
New Holland
Van Dimens Land
Terra Firma
SOUTH AMERICA
Brazil
Paraguay
Chili
Peru
Magellanica
Equator
Callapagos
GREAT SOUTH SEA
Solomons I.
Tropic of Capricorn
I. Fernandez
New Zeland
SOUTHERN OCEAN
INDIAN OCEAN
EASTERN OCEAN
Terra Australis
St. Helena
Ascension
Falkland I.
C. Horn
Plate II.
This shows the Form of the Earth & Sea in Wrights Delineation.
Page 48.

3. When the Sun is elevated above the Horizon, you ſuppoſe a Perependicular to drop down from the Sun to the Horizon, and from that Point in the Horizon to the true North Point in the Horizon, is the Sun's true Azimuth from the North. The Supplement or Remainder to 180 Degrees, is the true Azimuth from the South.

4. In North Latitude, the true Azimuth is reckoned from the true North Point of the Horizon; but in South Latitude, the true Azimuth is reckoned from the true South Point of the Horizon.

5. The falſe Azimuth is obſerved by the Compaſs Card, and is reckoned from the North Point of the Compaſs Card in North Latitude, but from the South Point of the Compaſs Card in South Latitude.

6. The true Azimuth from the North in North Latitude, and from the South in South Latitude, are each of them computed by this Rule.

1ſt. If the Declination and Latitude are either both North or both South, ſubtract the Declination from 90° but otherwiſe add the Drclination to 90° to get the Polar Diſtance.

2d. When the Sun's Altitude has been taken, if it is ſmall, ſubtract the Refraction from it as well as the Dip, to get the Altitude of the Centre.

3d. Add together the Co-latitude, the Co-altitude and the Polar Diſtance; take half that Sum, and from that Half Sum, ſubtract the Polar Diſtance to get a Remainder.

4th. Add together the Complement-arithmetical of the Co-latitude, the Complement-arithmetical of the Co-altitude, the Sine of the Half Sum and the Sine of the Remainder, take the Half Sum of theſe four Logarithms and find it in Logarithmic Sines.

5th. Take the correſpondent Co-ſine Arch and double it, this is the true Azimuth from the North in North Latitude, and from the South in South Latitude.

7. If the falſe Azimuth coincides with and is equal to the true Azimuth, the falſe North will coincide with the true North and there will be no Variation.

8. When the $\left\{\begin{array}{c}\text{true}\\ \text{falſe}\end{array}\right\}$ Azimuth in $\left\{\begin{array}{c}\text{North}\\ \text{South}\end{array}\right\}$ Latitude, is greateſt Beforenoon, the Variation is Eaſtwardly.

9. When the $\left\{\begin{array}{c}\text{true}\\ \text{falſe}\end{array}\right\}$ Azimuth in $\left\{\begin{array}{c}\text{North}\\ \text{South}\end{array}\right\}$ Latitude, is greateſt Afternoon, the Variation is Weſtwardly.

10. Count both the falſe and true Azimuth, from the North in North Latitude and from the South in South Latitude; then,

when the falſe and true Azimuths are of one Name, their Difference is the Variation.

11. When the falſe and the true Azimuths are of different Names, their Sum is the Variation.

SECTION XXVI.

DIRECTIONS for referring two Obſervations to one Station, when the Latitude is to be found by having two Altitudes and the Elapſed Time.

1. When a Ship in Motion is in an unknown Latitude, and her Latitude is to be determined by two Altitudes and the Elapſed Time; the Place where the firſt Altitude is taken, is called the firſt Station, and the Place where the ſecond Altitude is taken the ſecond Station.

2. If the Ship ſails due Eaſt or due Weſt directly {toward / from} the Sun all the Way; the Diſtance ſailed in Miles, are Minutes to be {ſubtracted from / added to} the Altitude taken at the ſecond Station, to reduce it to what it would have been at the firſt Station.

3. If the Ship ſails under any other Courſe, and directly toward the Sun all the Way, the Trace of the Ship will be a Curve, concave or convex to the neareſt Diſtance between the two Stations.

4. The Bearing of the Sun by the Compaſs, at the firſt Station, is the firſt Bearing, and at the ſecond Station, is the ſecond Bearing, their Difference is the Difference of the Bearings; and the Diſtance made good between the Stations, in Miles are Minutes of a Degree.

5. The Difference of the Bearings, is an Angle (at the firſt Station) of a Right Angled Plane Triangle; the Diſtance made good is it's Hypothenuſe, a Perpendicular drawn from the ſecond Station to the Line of firſt Bearing forms the Right Angle, and from the firſt Station to the Right Angle are the Miles (or Minutes) ſhewing the Increaſe or Decreaſe of Altitude between the two Stations.

6. When the ſecond Station is at Right Angles to the firſt Bearing, this Difference of Altitude is nothing.

7. When the ſecond Station is {advanced more toward / withdrawn more from} the Sun, than the firſt Station, the Difference of Altitude is {ſubductive from / additive to} the Altitude at the ſecond Station to reduce to what it would have been at the firſt Station.

8.

8. As the Radius or Sine of 90°
Is to the Diſtance made good in Miles;
So is the Coſine of the Difference of Bearings,
To the Difference of Altitude required.

9. When a Ship hath run under different Courſes and Diſtances from the firſt to the ſecond Station; the Courſe and Diſtance made good are to be found as in Traverſe Sailing.

10. The Diſtance made good thus found, is to be applied as a ſingle Courſe with its Diſtance beforementioned, to reduce the Altitude at one Station to what it would be at the other Station.

SECTION XXVII.

Directions for judging nearly what the Latitude is, from an Altitude of the Sun or Star, or the Moon cleared from Parallax in Altitude; when ſuch an Altitude is taken near the Meridian.

1. Where the Declination and Latitude are both North or both South, ſubtract the Declination from 90° but otherwiſe add it to 90° to get the Polar-diſtance.

2. When the Sun or other Celeſtial Body, is on the Meridian, the Co-altitude and Co-latitude together, are equal to the Polar-diſtance.

3. When the Sun or other Celeſtial Body is not on the Meridian, the Co-altitude and Co-latitude together, are greater than the Polar-diſtance.

4. When the Co-altitude and the ſuppoſed Co-latitude together are leſs than the Polar-diſtance, the ſuppoſed Co-latitude is too little, and the Latitude too great.

5. When the Co-altitude and the Polar-diſtance together are greater than the ſuppoſed Co-latitude, the Co-latitude is too great, and the Latitude too ſmall.

6. In either of theſe three laſt-mentioned Caſes, it will be ſhewn how to judge more nearly whether the ſuppoſed Latitude is too great or too little, and how to aſſume it nearer the Truth.

SECTION XXVIII.

Directions for finding the Latitude at Sea, by having two Altitudes of the Sun and the Time Elapſed between the Obſervations.

1. The Altitude of the Sun's lower Limb muſt be taken at the firſt Station, and cleared of Semidiameter, Refraction and Dip, to get the Altitude of the Centre.

2. The Bearing of the Sun at the firſt Station muſt be taken by the Compaſs, when the firſt Altitude is taken.

3. The Distance made good from the first Station to the second Station, must be found by Plain Sailing.

4. The Altitude of the Sun's lower Limb must be taken at the second Station, and cleared of Semi-diameter, Refraction and Dip, to get the Altitude of the Centre.

5. The Bearing of the Sun at the second Station must be taken by the Compass when the second Altitude is taken.

6. Having the two Bearings, the Distance between the two Stations, and the two Altitudes of the Sun's Centre; the Altitude of the Sun's Centre at the second Station must be reduced to what it would have been, if it had been taken at the first Station.

7. The Sun's Declination must be taken out as nearly as possible, what it is at the Middle between the two Observations for London or Greenwich, in Degrees and Minutes.

8. If the Declination and Latitude are supposed both North or both South, subtract the Declination from 90° but otherwise add the Declination to 90° to get the Polar Distance.

9. Take two Latitudes as near the truth as you can suppose, one of them that shewn by the Ship's Reckoning or any other way chosen, and the other a Degree, or more or less different therefrom; and such, that of the Co-latitudes, either of the Co-altitudes, and the Polar Distance, any two of the three may be greater than the third.

10. The first chosen Co-latitude, the Polar-distance, and the two observed Co-altitudes, will form two Computations; and the second chosen Co-latitude, the Polar-distance, and the two observed Co-altitudes, will form two other Computations.

11. The Elapsed-time must be found from the two first Computations, likewise from the latter Computations, by this Rule.

1st. Add together, the Co-latitude, the Polar-distance and Co-altitude, and from their half Sum subtract the Co-altitude, to get a Remainder.

2d. Add together the Complement-arithmetical of the Co-latitude, the Complement-arithmetical of the Polar-distance, the Sine of the half Sum and the Sine of the Remainder, and take half the Sum.

3d. Find this half Sum in Logarithmic-sines, take out the correspondent Cosine-arch and double it; this in Degrees, allowing 15 Degrees to an Hour of Time, is the computed Time from Noon, when that Observation was made.

12. Each of the two first Hour-angles, must be found by this Rule; likewise, each of the two second Hour-angles by the same Rule.

13. The measured Elapsed-time between the two observations, must be turned into Degrees, by allowing 15 Degrees to an Hour of Time.

14. When the $\left\{\begin{matrix}\text{Sum}\\ \text{Difference}\end{matrix}\right\}$ of the two Hour-angles thus found, agrees nearer with the measured Elapsed-time than their $\left\{\begin{matrix}\text{Difference}\\ \text{Sum}\end{matrix}\right\}$ the Observations were made $\left\{\begin{matrix}\text{one before, the other}\\ \text{both before or}\end{matrix}\right\}$ Afternoon.

15. When either the Sum or the Difference of the computed Elapsed-time, agrees with the measured Elapsed-time, the Latitude corresponding thereto is the true Latitude.

16. Take the Difference between the computed Elapsed-times in Degrees and Minutes; and the Difference between the two assumed Latitudes in Minutes of a Degree.

17. As the Difference between the computed Elapsed-times,
Is to the Difference between the assumed Latitudes;
So is the measured Elapsed-time,
To a number of Minutes, for the Correction.

18. If the Latitude thus found, gives the measured Elapsed-time, it is the true Latitude.

19. If neither of the assumed Latitudes agrees with the Latitude thus found, that Latitude nearest agreeing therewith (if it will work) is to be assumed, and the Operation made therewith as before to find the computed Elapsed Time.

20. Compare this newly computed Elapsed Time with one of the former Elapsed Times, by the forementioned Proportion, and it will give the Correction required.

21. When the Latitude is known, either by this Method, or by having the Meridian Altitude; (the Declination, and the Altitude being known) the time of the Day, either past Noon or what it wants of Noon, is found by the three steps in the foregoing Article.

22. If this computed Time agrees with that shewn by the Ship's Clock, it is right with Solar-time; but otherwise, it should be set forward or backward, or its Difference allowed for.

SECTION XXIX.

Directions for reducing the apparent Course to the true Course, by an Allowance for Lee-way and Variation, to have the true Rhomb.

1. Lee-way may augment or diminish the Angle which the Ship makes with the true Meridian. Variation may likewise augment or diminish the Angle made with the true Meridian.

2. Either the Sum or Difference of Leeway and Variation may be the Correction additive or subductive, to reduce the apparent Course to the true Course.

3. The

3. The true Course is every where the same, between any two places whose Bearing and Distance are to be expressed.

4. The Distance under this uniform Course, is no where coinciding with a Great Circle, except along a Meridian or the Equinoctial.

SECTION XXX.

Directions concerning the Plain Chart.

1. The Plain Chart may be used, within the Limits of about ten Degrees North and South of the Equinoctial; but in approaching toward the Poles, it becomes erroneous.

2. In the Plain Chart, the Degrees of Latitude and of Longitude, are equal to each other; each being 60 nautical Miles.

3. When a small part of the Earth or Sea is to be represented; the Meridians may be straight Lines parallel to each other. Likewise, the parallels of Latitude may be straight Lines parallel to each other, and at right Angles to the Meridians.

4. In the last-mentioned case, the Degrees of Latitude are equal. The Degrees of Longitude are also equal; but a Degree of Latitude is to a Degree of Longitude, as the Radius is to the Cosine of the Latitude.

SECTION XXXI.

Directions concerning the Bearings and Distances of Places, as shewn by the true Sea Chart.

1. The Parallel Bearings or Courses are shewn by the Compass-points on the Chart.

2. The Distances on the Meridians are shewn by the Degrees of Latitude.

3. Having the Bearing and the true Difference of Latitude; the Distance is found by this Rule. As the Cosine of the Course in Degrees and Minutes, is to the true Difference of Latitude in Miles; so is the Sine of 90° to the Distance in Miles.

4. In measuring obliquely and by Scale of equal Parts, the Scale must be a Medium of the Difference between what ariseth from the Equidistance of the Meridians and the Enlargement of the Degrees of Latitude.

SECTION XXXII.

Directions for using the Sinical Quadrant.

1. The Sinical Quadrant shews the lengths of the Natural Sines and Cosines, to every part of the Quadrant, the Radius being supposed Unity, or rather 10, or 100, or 1000, &c.

2. The

2. The Radius being equally divided; any number of Miles may be found therein, anſwering to the Diſtance ſailed.

3. In the Sinical Quadrant; any part of the Radius repreſenting the Diſtance ſailed is the Hypothenuſe of a right-angled plane Triangle, in which, the Baſe and Perpendicular are one of them the Difference of Latitude and the other of them the Departure; and the Courſe is the Angle at the Centre made with the Meridian.

4. Conſequently, the Sinical Quadrant, ſolves all the caſes of Plain Sailing, by Inſpection.

SECTION XXXIII.

Directions for uſing the Plain Scale.

1. The Plain Scale hath Equal Parts, Chords, Sines, Tangents, Semi-tangents Secants, &c.

2. The Equal Parts are uſed in laying down the Sides of Plane Triangles; the Chords in making or meaſuring their Angles; the Sines and Semi-tangents in Projections of the Sphere in Plano; the Tangents and Secants in the ſame doctrine.

3. Theſe Lines are likewiſe applicable in Dialling, but have not many other uſes in Navigation.

SECTION XXXIV.

Directions for the Conſtruction of Plane Triangles; alſo, for the Caſes of Plain and Mercator's Sailing.

1. Sides of Plane Triangles, are laid down by Scales of Equal Parts.

2. Angles of Plane Triangles, are laid down by Scales of Chords, or by the Protractor.

3. In Scales adapted for laying down Angles in Points of the Compaſs, the Points of the Compaſs are proportional to the Degrees contained in them.

4. The Chord of 60° is always the Radius of the Circle.

5. If a leſſer Scale be required than that which is conſtructed; you may uſe any part of the Radius for a Radius, provided you uſe the ſame proportional part, for the Chords af any of the Arches.

SECTION XXXV.

Directions concerning the Uſe of the Sector.

1. The Sector hath a Scale of Lines of Equal Parts; alſo, of Natural Sines, Tangents, Secants, &c.

2. The two Legs of the Sector have Lines alike, and alike graduated from the Centre to the End.

3. Either

3. Either Leg of the Sector may be used as a Scale of Equal Parts. But, when the Sector is otherwise used, it is thus,

4. In taking off any Distance or Length from the Sector, the two points of the Dividingcompass are extended from one division on the one Leg, to the like division on the other Leg of the Sector.

5. By this property, the Sector becomes an universal scale of Natural Sines, Tangents, &c. as well as Equal Parts, and thereby supplieth the use of many Scales.

6. Proportionally or Direct Proportion is performed by the Sector, thus. As any Number on one of the Legs; is to the Parallel Breadth from one Leg to the other, at any opening of the Sector; so is any other Number on the first mentioned Leg, to a Parallel Breadth from one Leg to the other, which is the fourth Number required.

7. Every operation on the Sector, in working Proportionality, depends on the doctrine of Similar Triangles.

8. The Sector, sometimes hath Gunter's Lines near the Edge of its Legs, which are worked by the help of a pair of Compasses.

SECTION XXXVI.

Directions concerning Gunter's Scales.

1. Gunter's Lines of Numbers, Sines, Tangents, &c. are of two kinds. The former are commonly called Scales and Compasses, the latter Sliding Gunters.

2. In Direct Proportionality, the Extent or Distance from the first Term to the second Term; is the same as the Extent or Distance from the third Term to the fourth Term.

3. In Multiplication, the first Term is Unity; and in Division, either the second or third Term is Unity.

4. Powers are raised by doubling, or trebling, &c. the distances from Unity. Roots are extracted by halfing, thirding, &c. the distances from the Powers.

5. In the Sliding Gunter's, the Slider supplies the use of the Compasses, by the correspondent numbers opposite to each other; therefore the same Rules hold for one as the other.

6. The Sliding Gunter's Line of Numbers, is sometimes thrown into the Circumference of a Circle by various methods.

SECTION XXXVII.

Directions for using the Rectifier.

1. The Rectifier consists of two Concentric Circles, each having in it's circumference the Degrees and correspondent Points of the Compass-card.

2. The lowermost circle represents the true Horizon, and the upper-

moſt circle, the Compaſs-card pointing out the falſe North, falſe South, falſe Eaſt and falſe Weſt.

3. When the Sun's true Amplitude is found, it is ſet off from the true Eaſt or true Weſt on the Rectifier to the place of the Sun.

4. The falſe Amplitude is then ſet off from the place of the Sun to the falſe Eaſt or falſe Weſt.

5. The Differenee between the true Eaſt and falſe Eaſt, or the true Weſt and falſe Weſt, or rather what they are apart from each other, which is ſometimes their Sum, is the Variation of the Compaſs.

SECTION XXXVIII.

Directions for the Uſe of Variation Charts.

1. A Variation Chart hath three principal Lines belonging to it, namely, 1ſt. Lines of the parallels of Latitude. 2d. Meridians ſhewing the Longitudes of Places on the Chart. 3d. Lines of Variation, ſhewing the Variation of the Compaſs at thoſe places on the Chart where they paſs.

2. Where the Latitude and Longitude Lines meet, the Variation is ſhewn on the Chart.

3. Where the Latitude and Variation Lines meet, the Longitude is ſhewn on the Chart.

4. Where the Longitude and Variation Lines meet, the Latitude is ſhewn on the Chart.

5. When the Latitude and Longitude are known ſomewhat near the truth; by knowing the Variation, it is ſhewn when the Sun or any Celeſtial Body is either near the Meridian, or any other true Point of the Compaſs.

SECTION XXXIX.

Directions for uſing the Croſs-ſtaff.

1. This Inſtrument conſiſts of two parts, a Staff ſeveral Feet in length, and another ſliding thereon, at right Angles, from one end toward the other.

2. The Obſerver having put on the Croſs or Slider, brings the End of the Staff to his Eye, whilſt his Sight is directed upward toward the Sun, by the upper End of the Croſs; and under, toward the Horizon by the lower End of the Croſs. Then, the Degrees on the Side of the Staff, ſhew the Altitude above the Horizon.

3. This Inſtrument has been long uſed, but it is now judged to be very imperfect.

SECTION XL.

DIRECTIONS for the Use of Davis's Quadrant.

1. Davis's Quadrant hath two Arches, a greater and a less; also, a Horizon Vane and two Sight Vanes.

2. The Horizon Vane is at the Centre. The Shade Vane is on the upper or lesser Arch. The Sight Vane is on the lower or greater Arch.

3. In observing with the Instrument, the observer turns his back to the Sun, and looking through the Eye-hole in the Sight Vane, sees the Horizon and either the Image or Shade from the Sun, united in the Horizon Vane.

4. The Sum of the Degrees and Minutes on both the Arches, between the Sight Vane and Shade Vane, is the Altitude required.

5. This Instrument is now used by foreigners and many English Mariners.

SECTION XLI.

DIRECTIONS for using the Astrolabe.

1. This Instrument is held freely by its Ring, and its Index is put so that the Image of the Sun may pass from the upper to the lower part thereof, diametrically.

2. The Degrees and Minutes from the Horizontal Line, to either the upper or lower part of the Index (that which is nearest) is the Altitude required.

3. This Instrument has been by some, much approved of, but is now thought of little use.

SECTION XLII.

DIRECTIONS for keeping a Sea Journal.

1. A Sea Journal is the principal Book for shewing the place of the Ship, and what places she hath been at during a Voyage, with an Account of what has happened.

2. At Sea, the Day is supposed to begin at Noon, and to be reckoned on 12 Hours to Midnight, and 12 Hours more to the next day at Noon; 24 Hours in all.

3. To be correct, every Course should be cleared from Lee-way and Variation; but when several Courses are nearly alike, the Medium of them may be taken, and that cleared, to get the true Course.

4. When Eight Fathoms of the Log-line make one Knot, it will not be so easy to sum up the Distances sailed, as when Ten Fathoms make a Knot; because the latter agrees with the common scale of Whole Numbers.

5. Every Day at Noon the Journal is to ſhew the following particulars, namely. 1ſt The Courſe made good during the laſt 24 Hours. 2d The Diſtance made good. 3d The Difference of Latitude, Northing or Southing. 4th The Departure Eaſting or Weſting. 5th The Meridian Diſtance, which is the Departure made good in Degrees and Minutes, from the laſt Land, the Ship departed from; reckoning 60 Miles of Departure to a Degree. This is but of little uſe in the Journal. 6th The Latitude in by Account. 7th The Difference of Longitude made. 8th The Longitude in. 9th The Bearing and Diſtance of the Land the Ship took her Departure from.

SECTION XLIII.

Directions for uſing the Terreſtrial Globe.

1 To find the Diſtance of any two places.

Meaſure it with the Quadrant of Altitude or a Pair of Compaſſes, and each Degree of Diſtance is 60 Nautical Miles or 69½ Engliſh Miles.

2. To find the Latitude of a place.

Bring the place to the Braſs Meridian, and the Latitude, North or South, is the Diſtance from the Equinoctial, in Degrees and Minutes.

3. To find the Longitude of a place.

Bring the place to the Braſs Meridian, and the Longitude Eaſt or Weſt, is the Diſtance from the Meridian of London, in Degrees and Minutes; counting on the Equinoctial.

4. To find thoſe places of the Earth, where the Sun is Vertical at Noon, on any given Day.

Find how much the Sun is Northward or Southward of the Equinoctial at Noon by the Scale of Declination for that purpoſe, or by his place in the Ecliptic; and all the places in that Circle and at that Diſtance from the Equinoctial, are thoſe required.

5. To find where the ſun is Vertical, at a given Hour of a given Day.

Find at what Diſtance the Sun is from the Equinoctial, North or South thereof by the former problem. Then reckoning 15 Degrees to an Hour of Time; count as many Hours to the Eaſtwaad or Weſtward, on the Equinoctial, as is the given Hour, and in that Meridian at the forementioned Diſtance North or South of the Equinoctial, is the place required.

6. To ſhew the illuminated and unilluminated Hemiſphere, for a given time.

Find where the Sun is Vertical; and 90 Degrees therefrom, all round, is the Great Circle, ſeparating the illuminated and unilluminated Hemiſpheres. The Places reſpectively, are as many Degrees

grees above the Horizon of the Globe, as the Sun is at that time elevated above the Horizon at thoſe places.

7. To find on what Point of the Horizon, one place bears from another place that is given.

Bring the given place uppermoſt (which is done by turning it to the Braſs Meridian and elevating the Pole to the Latitude of the place). Then the Quadrant of Altitude being laid from the given place and paſſing over the other place, ſheweth the Degrees on the Horizon which is the Bearing required.

8. The Bearings of places are not from each other on Oppoſite Points of the Compaſs, unleſs they are in the ſame Meridian; or in the Equinoctial Line.

9. The Bearings of places are the Angles of a Spherical Triangle, and the Diſtances are the Sides.

SECTION XLIV.

Directions for uſing the Celeſtial Globe.

1. To ſet the Celeſtial Globe to the Latitude of a place.

Elevate the Pole of the Globe, as many Degrees and Minutes above the Horizon, as is the Latitude of the place; the North Pole for North Latitude, and South Pole for South Latitude; and it is the Elevation required.

2. To ſet the Globe to the Latitude of a place and to the Sun's Place in the Ecliptic; and ſolve the Problems depending on theſe adjuſtments.

Elevate the Globe to the Latitude of the place; and having found the Sun's Place in the Ecliptic for the given Day, bring it to the Braſs Meridian, and turn the Hour Index to 12.

The Globe being thus adjuſted, will ſolve theſe following Problems, without any other adjuſtment.

1ſt. Turn the Sun 18 Degrees under the Eaſtern Horizon, and the Hour Index ſhews the time of the Beginning of Twilight.

2d. Turn the Sun to the Eaſtern Horizon, and the Hour Index ſhews the time of Sun Riſing.

3d. At the ſame time the true Amplitude of Sun-Riſing is ſhewn on the Horizon.

4th. The Sun being over the Eaſt Point of the Horizon; the Hour Index ſhews when the Sun is due Eaſt; and his Height or Altitude at that time may be meaſured.

5th. Turn the Hour Index to 6 Hours Eaſtward; and the Altitude at that time may be meaſured; alſo, by dropping a Perpendicular on the Horizon, his Azimuth from the North or South Point of the Horizon at that time.

6th. Turn the Globe to any other Hour, ſo that the Sun is ſhort of the Meridian; and his Altitude, alſo his Azimuth, is ſhewn in the ſame manner.

7th. If

7th. If it be turned to a given Altitude, the Hour and Azimuth are ſhewn.

8th. If it be turned to a given Azimuth, the Hour and Altitude are ſhewn.

9th. Turn the Sun to the Braſs Meridian, and his Meridian Altitude is ſhewn. Alſo, his Declination North or South of the Equator. Alſo, the fixed Stars that are above the Horizon at Noon, in their reſpective ſituations, altitudes, azimuths, &c.

10th. The Stars then on the Eaſt-ſide of the Meridian are increaſing in Altitude, but thoſe on the Weſt ſide are decreaſing.

11th. Turn the Sun to the Weſtward of the Meridian, and the ſame Problems may be ſolved for the Afternoon.

12th. Turn the Sun any where below the Horizon, and all the Problems ariſing from the Situations of the Fixed Stars are eaſily ſolved by inſpection.

3. The Places of the Moon and Primary Planets being found either in or near the Ecliptic, the ſame Problems may be ſolved concerning them as for the Fixed Stars.

4. The Circumpolar Stars that do not ſet in the given Latitude; have two Meridian Altitudes; one below and the other above the Pole.

5. The Stars that never ſet, have their Polar Diſtances, not exceeding the Latitude of the place; except, a ſmall addition ariſing from the effect of Refraction.

6. The Stars which have not a greater Diſtance from the oppoſite Pole than the Latitude of the place, do not appear in that Latitude, except with a very ſmall Altitude, occaſioned by Refraction.

7. The Degree or Point of the Equator on the Meridian with the Sun, is his Right Aſcenſion. The Point of the Ecliptic is his Longitude.

8. The Degree or Point of the Equator Riſing with the Sun is his Oblique Aſcenſion. That ſetting with the Sun is the Oblique Deſcenſion.

9. The Difference between the Right and Oblique Aſcenſion, is the Aſcenſional Difference, or Difference between the time of Sun Riſing and 6 o'clock.

10. Like Solutions ariſe concerning the Fixed Stars, the Planets, and the Moon; except, that they have Latitude North or South, perpendicularly to the Ecliptic, and that a ſmall difference ariſeth from the Moon's Horizontal Parallax at her Riſing and Setting, and different Degrees of Altitude.

11. Medium Cœli, is the point of the Ecliptic on the Meridian.

12. The Angle made with the Meridian and Ecliptic, is continually changing.

SECTION

SECTION XLV.

DIRECTIONS for Projecting the Sphere on the Plane of the Meridian Stereographically.

1. One Diameter represents Half of the Equator and that at Right-angles thereto, the Six o'Clock Hour Circle.

2. All other Meridians are Arches of Circles, set off with the Semi-tangent of their Distances respectively from the Six o'clock Hour-circle, and drawn through the Poles.

3. A Tangent at that distance sets them off from the Centre of the Circle; and a Secant of the same draws them.

4. For lesser Circles, parallel to the Equator, a Semi-tangent sets them off from the Centre; and a Chord at the Circumference.

SECTION XLVI.

DIRECTIONS for Projecting the Sphere on the Plane of the Meridian Orthographically.

1. The Diameters drawn at Right Angles to each other, are the same as in the Stereographic Projection.

2. The Meridians are Ellipses; the lesser Circles parallel to the Equator, are straight Lines, meeting the Chords in the Arches.

3. All great Circles passing through the Centre, are straight Lines.

4. This Projection (likewise the Stereographic Projection) is applicable for the Solution of Spherical Problems by Inspection.

SECTION XLVII.

DIRECTIONS for computing Great Circle Sailing.

1. In a Right-angled Spherical Triangle, the Base and Perpendicular, the Complement of the Hypothenuse, and the Complement of the two adjoining Angles, are the five Circular Parts.

2. The Sine of a Middle Part together with Radius, makes the Tangents of the next adjoining parts, and the Cosines of the Parts not next adjoining.

3. In any Spherical Triangle; the Sines of the Sides, are directly as the Sines of the opposite Angles.

4. As the Tangent of the Half Base, is to the Tangent of the Half-Sum of the Sides; so is the Tangent of the Half Difference of the Sides, to the Tangents of the Half Difference of the Segments of the Base.

5. The Difference of Longitude of two places, is an Angle at one of the Earth's Poles.

6. The Distance of two places in the arch of a Great Circle, is one Side of a Spherical Triangle; and the other two Sides, are the

Co latitudes of the places sailed from and to.

7. When Great Circle Sailing is applied duely North and South, the ship sails on a Meridian; but at the Equinoctial it sails along the Equinoctial Line.

8. At other Places and under other Courses, it cuts the Meridians under different Angles, and alters the Course at every part of the Track.

SECTION XLVIII.

Directions for finding the Distance of one Place from another by the Motion of Sound.

1. By Experiments, Sound moves in the open air 1200 English feet, or 400 Yards in a Second of time.

2. When it strikes against Objects at near Distances and is reflected from them, it moves 1140 English feet or 380 Yards in a Second of time.

3. Multiply the number of Seconds it is in motion, by the Distance it goes in a Second the Product is the Distance.

4. Divide the Distance by its motion per Second, and the Quotient is the time of it's flight.

5. A Pendulum $39\frac{2}{10}$ Inches; also a Pocket-watch will give the Interval of time.

6. The Interval between the Appearance of the Flash and hearing the Report of a Gun, is the time of its motion. So is that between seeing the Lightening and hearing its Thunder.

7. This method may be of use at Sea, and near the Coasts; where great exactness is not wanted.

SECTION XLIX.

Directions for taking a Sketch of the Coast.

1. Distances may be taken somewhat near the truth by the Motion of Sound.

2. Angles may be taken either by the Sextant or by the Octant.

3. Other Distances and Positions my be inferred from the properties of Plane Triangles.

4. Intermediate Objects may be drawn on the Spot, as they are supposed accurately to be, by their Appearance to the Eye.

5. Rocks above or under Water, Sands, Soundings, &c. may be laid down by this method, near the truth; where Accuracy cannoi be had.

SECTION L.

DIRECTIONS for correcting the Errors in Spherical Computations, which arise from the Spheroidical Figure of the Earth.

1. In Spherical Computations, the Earth and Sea together are commonly supposed a perfect Sphere or Globe.

2. The true Figure of the Earth is that of a Spheroid, flattened toward the Poles.

3. Near the Latitude of 45° North or South, a Perpendicuiar to the Meridian deviates from a direction towaad the Centre, near a third part of a Degree.

4. The horizontal Tangents in that Latitude under a North-east and South-west Direction; also, under a North-west and South-east Direction; are different from what they would be, if the Earth was a perfect Sphere.

4. The Spheroidical Horizon must be reduced to the Spherical one, before the Calculations depending thereon can agree with those of Spherical Triangles.

6. The Computations for Time at the Ship; also, for the true Azimuth, require this Correction.

7. When Observations are made near the due East or West points of the Horizon, this error may in a greet measure be avoided.

8. When Observations are made near the Meridian the same Advantages follow; but then there is frequently a great disadvantage on account of the slow advance in Altitude of the Sun or Stars.

SECTION LI.

DIRECTIONS concerning Logarithms.

1. Index 10. with Cyphers, is the Logarithm of Radius. Index 20. with Cyphers, is the double Logarithm of Radius.

2. Subtract the logarithmic Sine from the double Logarithm of Radius; remains the logarithmic Co-secant.

3. Subtract the logarihtmic Tangent from the double Logarithm of Radius; remains the logarithmic Co-tangent.

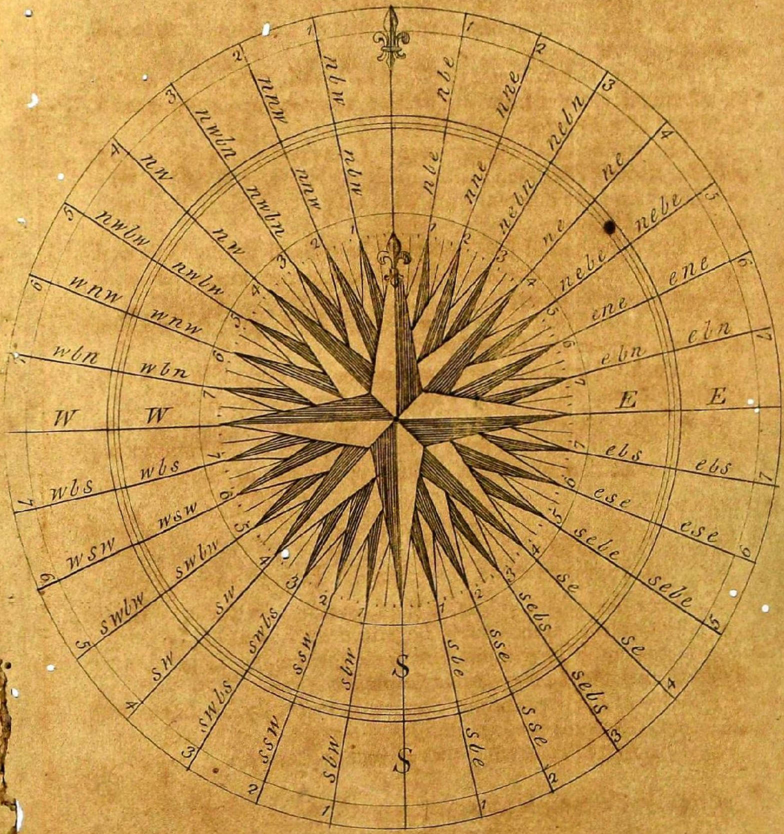
4. The Sine of an Arch is that of its Supplement.

360 Propositions and Institutes.

12th July, 1781. S. DUNN.

THE END.

An Improved Compass Card & Rectifier.



N.B. The Degrees are shewn by the Table.

The innermost Points being cut round & taken out & the other pasted on a Card, & both Parts being made concentrical by a thread, the Rectifier is made.

S. Dunn delin.t

Published according to Act of Parliament Nov.r 17th 1777 by S. Dunn.

Page 58. & 110.

The Points & Degrees of the Compass Card.

North	South.	Points	D . M.	North	South
			2 . 49		
			5 . 37		
			8 . 26		
N. by E.	S. by E.	1	11 . 15	N. by W.	S. by W.
			14 . 4		
			16 . 52		
			19 . 41		
N.N.E.	S.S.E.	2	22 . 30	N.N.W.	S.S.W.
			25 . 19		
			28 . 7		
			30 . 56		
N.E.bN.	S.E.bS	3	33 . 45	N.W.bN.	S.W.bS.
			36 . 34		
			39 . 22		
			42 . 11		
N. East	S. East	4	45 . 0	N. West	S. West
			47 . 49		
			50 . 37		
			53 . 26		
N.E.bE.	S.E.bE.	5	56 . 15	N.W.bW.	S.W.bW.
			59 . 4		
			61 . 52		
			64 . 41		
E.N.E.	E.S.E.	6	67 . 30	W.N.W.	W.S.W.
			70 . 19		
			73 . 7		
			75 . 56		
E. by N.	E. by S.	7	78 . 45	W. by N.	W. by S.
			81 . 34		
			84 22		
			87 . 11		
East.	East.	8	90 . 0	West.	West.

S. Dunn delin.t

Published Nov.r 17.th 1777, by S. Dunn.

FORMS.
For Time and Azimuths at Sea.

For Hour Angles à Noon.

Co. lat. 38°. 29'
à Pole 72 . 32
Co. alt. 57 . 21 — 0.2060
2) 168 . 22 — 0.0205
½ Sum 84 . 11 .... 9.9978
Rem.r 26 . 50 .... 9.6546
2) 19.8789
29°. 34' 9.9394
2
15) 59 . 8 (3h. 56'. 32"

Co. lat. 38°. 29'
à Pole 112 . 21
Co. alt. 87 . 32 — 0.2060
2) 238 . 22 — 0.0339
½ Sum 119 . 11 .... 9.9410
Rem.r 31 . 39 .... 9.7199
2) 19.9008
26°. 52' 9.9504
2
15) 53 . 44 (3h. 34'. 56"

For Azimuth Angles.

Co. lat. 38°. 29'
Co. alt. 57 . 21
à Pole 72 . 32 — 0.2060
2) 168 . 22 — 0.0747
½ Sum 84 . 11 .... 9.9978
Rem.r 11 . 39 .... 9.3052
2) 19.5837
38°. 15 9.7918
2
76 . 30 Azimuth

Co. lat. 38°. 29'
Co. alt. 87 . 32 — 0.2060
a Pole 112 . 21
2) 238 . 22 — 0.0004
½ Sum 119 . 11 .... 9.9410
Rem.r 6 . 50 .... 9.0754
2) 19.2228
65°. 52 9.6114
2
131 . 44 Azimuth

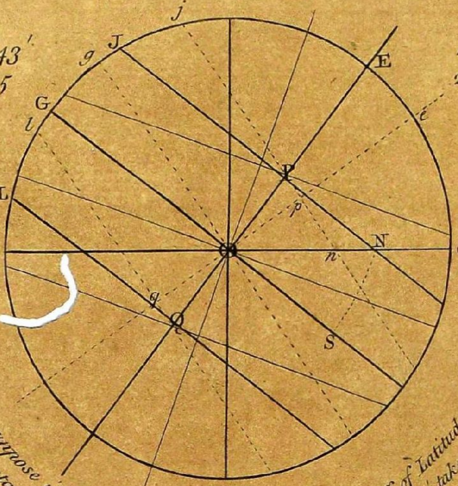
For the Preparation and Corrections,
See the Precepts at large.

S. Dunn delin.t

Published according to Act of Parliament Nov.r 17.th 1777. by S. Dunn.

Data.
Polar dist. 78°.43'
Elap. time 21.15

Data.
1.st Co alt. 43°.5
2.d Co alt. 35.53



Assume the Latitude twice, as suppose it is 46°.20' or 46°.36', with which & the Data, get the two hour Angles, & the false elapsed times will be 20°.34' & 21°.42', the diff. is 68' & the diff. of Latitude 16'. From the true elapsed time 21°.15' take 20°.34' remains 41'. As 68 to 16', so 41' to 10', which added to 46°.20' gives 46°.30' the true Latitude of the Place required.

Calculation.

Lat.	46 . 20			Lat.	46 . 20		
Co. lat.	43 . 40	Co. ar.	0 . 16086	Co. lat.	43 . 40	Co. ar.	0 . 16086
à Pole	78 . 43	Co. ar.	0 . 00848	à Pole	78 . 43	Co. ar	0 . 00848
Co. alt	43 . 5			Co. alt.	35 . 53		
2	165 . 28			2	158 . 16		
	82 . 44	Sine	9 . 99650		79 . 8	Sine	9 . 99214
	39 . 39	Sine	9 . 80489		43 . 15	Sine	9 . 83581
		2	19 . 97073			2	19 . 99729
	14 . 47		9 . 98536		4 . 30		9 . 99864
∠	29 . 34		is 20°.34' Diff.	∠	9 . 0		

Lat.	46 . 36			Lat.	46 . 36		
Co. lat.	43 . 24	Co. ar.	0 . 16299	Co. lat.	43 . 24	Co. ar	0 . 16299
à Pole	78 . 43	Co. ar.	0 . 00848	à Pole	78 . 43	Co. ar	0 . 00848
Co. alt	43 . 5			Co. alt	35 . 53		
2	165 . 12			2	158 . 0		
	82 . 36	Sine	9 . 99637		79 . 0	Sine	9 . 99195
	39 . 31	Sine	9 . 80366		43 . 7	Sine	9 . 83473
		2	19 . 97150			2	19 . 99815
	14 . 36		9 . 98575		3 . 45		9 . 99907
∠	29 . 12		is 21°.42' Diff.	∠	7 . 30		

...blished as the Act directs July

A Table of REFRACTION in ALTITUDE, by S. Dunn, Teacher of Mathematics LONDON.

Alt.ᵈ ° ′	Refracⁿ ′ ″	Alt.ᵈ ° ′	Refracⁿ ′ ″	Alt.ᵈ ° ′	Refracⁿ ′ ″	Alt.ᵈ ° ′	Refracⁿ ′ ″	Alt.ᵈ ° ′	Refracⁿ ′ ″	Alt.ᵈ °	Refracⁿ ′ ″	Alt.ᵈ °	Refracⁿ ′ ″	Alt.ᵈ °	Refracⁿ ′ ″
.0	34.27	.30	28.57	1. 0	24.32	3. 0	14.28	5. 0	9.40	8.	6.24	37.	1.12	66.	.25
.1	34.15	.31	28.47	.4	24.3	.4	14.12	.6	9.28	9.	5.43	38.	1.9	67.	.23
.2	34.3	.32	28.37	.8	23.35	.8	13.56	.12	9.16	10.	5.10	39.	1.7	68.	.22
.3	33.51	.33	28.28	.12	23.8	.12	13.44	.18	9.4	11.	4.43	40.	1.5	69.	.21
.4	33.39	.34	28.18	.16	22.42	.16	13.32	.24	8.56	12.	4.19	41.	1.2	70.	.20
.5	33.27	.35	28.9	.20	22.17	.20	13.20	.30	8.51	13.	3.58	42.	1.0	71.	.19
.6	33.15	.36	27.59	.24	21.52	.24	13.8	.36	8.45	14.	3.40	43.	.58	72.	.18
.7	33.3	.37	27.49	.28	21.28	.28	12.56	.42	8.39	15.	3.24	44.	.56	73.	.17
.8	32.51	.38	27.40	.32	21.4	.32	12.44	.48	8.33	16.	3.9	45.	.54	74.	.16
.9	32.40	.39	27.31	.36	20.40	.36	12.32	.54	8.27	17.	2.56	46.	.52	75.	.15
.10	32.29	.40	27.23	.40	20.16	.40	12.20	6. 0	8.21	18.	2.45	47.	.51	76.	.14
.11	32.17	.41	27.13	.44	19.52	.44	12.12	.6	8.10	19.	2.35	48.	.49	77.	.13
.12	32.6	.42	27.4	.48	19.31	.48	12.4	.12	8.4	20.	2.26	49.	.47	78.	.12
.13	31.55	.43	26.55	.52	19.11	.52	11.56	.18	7.58	21.	2.18	50.	.46	79.	.11
.14	31.44	.44	26.46	.56	18.51	.56	11.48	.24	7.52	22.	2.11	51.	.44	80.	.10
.15	31.33	.45	26.37	2. 0	18.31	4. 0	11.40	.30	7.46	23.	2.5	52.	.42	81.	.9
.16	31.22	.46	26.28	.4	18.15	.4	11.32	.36	7.39	24.	2.0	53.	.41	82.	.8
.17	31.11	.47	26.19	.8	17.56	.8	11.24	.42	7.33	25.	1.55	54.	.39	83.	.7
.18	31.0	.48	26.10	.12	17.36	.12	11.16	.48	7.27	26.	1.50	55.	.38	84.	.6
.19	30.49	.49	26.2	.16	17.16	.16	11.8	.54	7.21	27.	1.46	56.	.37	85.	.5
.20	30.39	.50	25.54	.20	16.57	.20	11.0	7. 0	7.15	28.	1.41	57.	.35	86.	.4
.21	30.29	.51	25.45	.24	16.39	.24	10.52	.6	7.9	29.	1.37	58.	.34	87.	.3
.22	30.18	.52	25.36	.28	16.21	.28	10.44	.12	7.3	30.	1.33	59.	.33	88.	.2
.23	30.8	.53	25.27	.32	16.3	.32	10.36	.18	6.57	31.	1.29	60.	.31	89.	.1
.24	29.57	.54	25.18	.36	15.47	.36	10.28	.24	6.51	32.	1.26	61.	.30	90.	.0
.25	29.47	.55	25.10	.40	15.31	.40	10.20	.30	6.45	33.	1.23	62.	.29		
.26	29.37	.56	25.2	.44	15.25	.44	10.12	.36	6.39	34.	1.20	63.	.28		
.27	29.27	.57	24.54	.48	15.9	.48	10.4	.42	6.33	35.	1.17	64.	.27		
.28	29.17	.58	24.46	.52	14.53	.52	9.56	.48	6.27	36.	1.14	65.	.26		
.29	29.7	.59	24.39	.56	14.40	.56	9.48	.54	6.24						

Diffce of Refraction for each Minute of Altitude 11″.

Diffce of Refraction for each Minute of Altitude 9″.

Diffce of Refracn for 4′ Altitude 25″.

Diffce of Refracn for 4′ Altitude 18″.

Diffce of Refracn for 4′ Altitude 12″.

Diffce of Refracn for 4′ Altitude 16″.

For 6′ Alt. 14″.

For 6′ Alt. 8″.

For 6′ Alt. 8″.

Here the Differences of Refraction are for 60′ Altitude.

Here the Differences of Refraction are for 60′ Altitude.

Here the Differences of Refraction are for 60′ Altitude.

* Between No. 65 & 66 Fleet street.

Removed from Clements Inn and from Maiden Lane.

Published according to Act of Parliament July 14th 1780, by S. Dunn No. 1. Boars-head Court Fleet street.*